

Invasive alien plants in China: diversity and ecological insights

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Abstract China's current invasive alien plant species were analyzed with regard to their floristic status, biological attributes and invasion status elsewhere. Most of the 270 species identified were annuals, followed by perennial herbs. Woody perennials made only about 10% of the species. The invasives were comprised of 59 families, the largest being Asteraceae, Poaceae, and Brassicaceae. The genera with most invasive species were *Amaranthus*, *Ipomoea*, and *Solanum*. Most of the species originated from the New World, notably from South America. About one-third of the species were serious invaders of natural habitats in countries other than China. The proportion of invasive alien plants in province floras ranged from 0.5 to 3.8%, absolute numbers from nine to 117 species per province. Density of invasive species was correlated positively with native species density at provincial scale. The results demonstrate that in China invasive plants are present throughout the country, with a particularly high species richness

in the Southeast. The ecological diversity of invasive plants suggests wide ranging impacts which need to be assessed.

Keywords Alien species · Asia · China · Flora · Invasive alien species

Introduction

The movement of species by man beyond natural dispersal barriers is a still accelerating process, resulting from global commerce and disturbance of natural ecosystems. Species introductions lead to biological invasions, which can have profound impacts on the regional economy and the ecological integrity of natural communities (Mooney and Hobbs 2000; Pimentel 2002). The number of alien plant species varies considerably among regions (Vitousek et al. 1997), and both socio-economic factors such as human density and degree of urbanization as well as biogeographic factors such as latitude and climate have been identified to correlate with alien species richness (Lonsdale 1999; Rejmánek 2000).

There is also considerable variation in the degree of knowledge of invasive alien species among various regions of the world. Plant invasions and alien floras of North American, Australian and European areas are well documented, whereas many countries of Asia are still understudied (Wu et al. 2004b).

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Compilations of alien weeds or naturalized species for Asian countries and regions other than China are available for Japan (Enomoto 1999), Korea (Koh et al. 2000), the city of Singapore (Corlett 1988, 1992), the city of Chonju, Korea (Zerbe et al. 2004), the Kashmir Himalaya (Khuroo et al. 2007), and Doon Valley, Northwest Himalaya (Negi and Hajra 2007). The most comprehensive study for an east Asian region is probably that for Taiwan (Wu et al. 2004a). Compiling alien floras and analyzing patterns of floristic status, biological attributes, and geographical distribution has proved to be a useful approach to understanding alien species richness in various regions (Rozefelds et al. 1999; Stadler et al. 2000; Pyšek et al. 2004; Pyšek and Richardson 2006), and such datasets represent the necessary baseline information upon which management strategies can be built.

China is the world's third largest country in relation to territory, stretching 5,200 km from east to west, and spanning 50° of latitude. Its vast territories cover five climatic zones: tropical, subtropical, warm-temperate, temperate, and cold-temperate (Wang et al. 1997). The complex topography and the wide range of habitats make the country be one of the richest in terms of biological diversity, harbouring approximately 31,000 vascular plant species or one-eighth of the world's total (Flora of China 2007).

China currently undergoes a rapid economic development and increasing international trade, translating into ecological side effects that are of direct significance for the spread of weeds and invasive species, e.g. construction of new roads and railways, increased disturbance, ecological construction, and increased species introductions (Liu et al. 2003; López-Pujol et al. 2006). All these may promote the spread of invasive species and increasingly threaten the integrity and diversity of China's unique ecosystems and species. Trade is believed to be a major vector for the introduction of harmful alien species (Convention on Biological Diversity 2002; Levine and D'Antonio 2003), and transport ways allow invasive species to reach remote yet uncolonized areas (Forman and Alexander 1998). The increasing trade between the United States and China (Callaway et al. 2006; Jenkins and Mooney 2006) is likely to onset further invasions, as well as increasing trade with other parts of the world.

The problem of invasive alien species in China has been addressed by a number of authors at both national and regional scales (Guo 1995; Guo and Li 1995; Qiang and Cao 2000; Li et al. 2001; Pan and Tian 2001; Xiang et al. 2002; Xie et al. 2001; Du et al. 2002; Li and Chen 2002; Li and Xie 2002; Chen et al. 2005). The estimated economic losses in China due to invasive alien species amount to US\$ 15 billion annually (Xu et al. 2004). Removal of water hyacinth (*Eichhornia crassipes*) in Wenzhou city cost 128 million US\$ in 1996 (Ding and Xie 1996). An estimate for the economic loss caused by *Mikania micrantha* on Neilingding Island ranges from 0.56 to 1.26 million US\$ (Zhong et al. 2004). Data on ecological damages are rather scarce. Zhang et al. (2003) outlined potential ecological damages by the spread of fanwort (*Cabomba caroliniana*). In parts of Dianchi Lake of Yunnan province, the vigorous growth of water hyacinth outcompeted native hydrophytes, reducing the species number from 16 to 3 (Wu 1993). These few figures indicate the high potential of costs and damages, both ecological and economic, associated with plant invasions in China.

An analysis of regional distribution patterns of invasive alien plant species in China (Liu et al. 2005) showed that species richness among provinces was mainly associated with native species richness and socio-economic factors such as human population density. The currently known invasive alien plant species have, however, not yet been characterized in terms of their ecology and status in other parts of the world. Here, we present such an analysis, based on a literature survey. We address the following basic questions: (1) What is the current number of invasive alien plants in China and what is their status in other places of the world? (2) From where do these species originate? (3) Which growth strategies contribute most to invasive plants? (4) Are biogeographic regions within China different with regard to invasive plants?

Methods

Data sources

We consider here only plant species that are alien to China and that are currently invasive. We could not consider the whole array of naturalized alien plant

species because compiling such a list is not feasible. The term ‘invasive species’ is used in the sense of McNeely et al. (2001), meaning that they cause damage to species, habitats, or to the economy, and the same definition has been adopted in the sources given below.

The species list was compiled from published literature, e.g. research articles, books and book chapters, and reports (Guo 1995; Guo and Li 1995; Zhang and Han 1997; Ding and Wang 1998; Li 1998; Hsu 1999; Qiang and Cao 2000; Pan and Tian 2001; Xie et al. 2001; Du et al. 2002; Li and Xie 2002; Liu et al. 2002; Xu et al. 2004; Tian 2004; Wu et al. 2004a; Liu et al. 2005; Qiang 2005; Lu et al. 2006; Xu et al. 2006a). A number of species are considered as invasive in some parts of China by the above references, whilst they are native to other parts of the country. These species were not considered in our analyses. Whereas it could not be excluded that plant materials of some of these species were introduced from other parts of Eurasia outside of China, we strictly focused on alien species in our analyses. For a number of species, e.g. *Bunias orientalis*, *Berteroa incana*, uncertainty exists with regard to native or alien status in China. The Flora of China checklist database (Flora of China 2007) considers these two species as native, and we therefore excluded them from our analyses. Other species such as *Narcissus tazetta* represent old introductions (Flora of China 2007) and hence alien to China. Because this species is considered as a noxious weed, we did include it.

Characterization of species

The species entries were supplemented with data on taxonomic position (family), life form and habitats, origin and distribution within China. Origins were extracted from the sources above and complemented by data on the native range. These were taken from the Germplasm Resources Information Network (USDA 2007).

We indicated the status of the species outside of China (invasive in natural areas elsewhere or not). The latter was granted to a species only if it is a serious invader of natural areas, according to Cronk and Fuller (1995), Daehler (1998), and Weber (2003). The status is called ‘invasive elsewhere’ hereafter.

We used ‘invasive elsewhere’ as an indicator for the invasion potential of the respective species. Status as invasive (or weedy) in other countries than the country under consideration is believed to be one of the best predictors of invasibility in plants (Groves et al. 2001).

For 221 species, we could obtain presence-absence data among provinces. For 181 species, we could gather data on habitat types in which the species occur. Habitat type refers to a broad categorization of natural and man-made habitats, e.g. natural forests, lakeshores and river edges, coastal areas, tree plantations and afforestation sites (by native or exotic species), road- and railway sides, grassland and pastures. Information on economic uses of each species was obtained from the above sources and complemented by Wiersema (1999). Economic uses indicate the introduction mode (accidental vs. intentional) and the purpose for introduction in the case of intentionally introduced species. A species was allocated to more than one category if different uses apply to it.

Data analyses

Analyses comprised of cross-tabulations and correlations. Provinces were taken as spatial units and species density in a province was expressed as $D = N/\log(A)$, where N is the number of species and A the area (Rejmánek and Randall 1994). Correlations were used to analyse relationships between invasive and native species density and richness, respectively, among provinces.

To analyse patterns of similarity among major geographic regions in China, we allocated provinces to four main regions (Fig. 1), e.g. the high plateaus of western China (West), the provinces with subtropical climate not bordering the sea (Central), northeastern provinces (Northeast), and southern provinces bordering the sea (South). Index of similarity (S) of these regions was calculated according to Sørensen (McGarigal 2000) using species richness in these regions as

$$S = (2C/A+B) \cdot 100$$

where C is the number of common species; A and B are the total numbers of species in regions A and B , respectively.

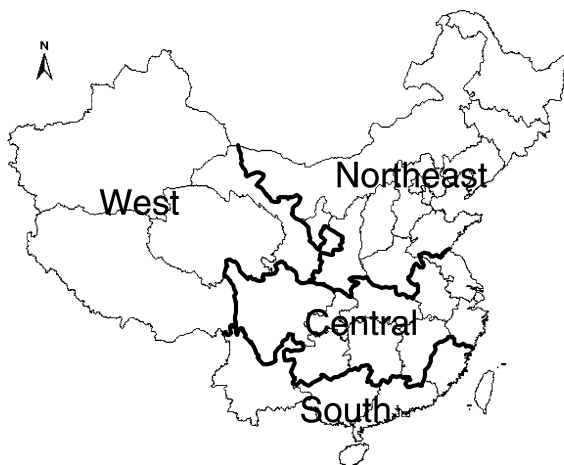


Fig. 1 Regions based on provinces for determining species overlap

Results

Numbers of invasive plant species and geographic distributions

We identified 270 invasive plant species, corresponding to 0.9% of the flora of China. They formed a heterogeneous group with regard to taxonomic position and ecological attributes, and are listed in Appendix 1. At least one-third of the species (36.3%) was invasive elsewhere. The number of invasive species among provinces showed considerable variation (Fig. 2), with the lowest species richness in

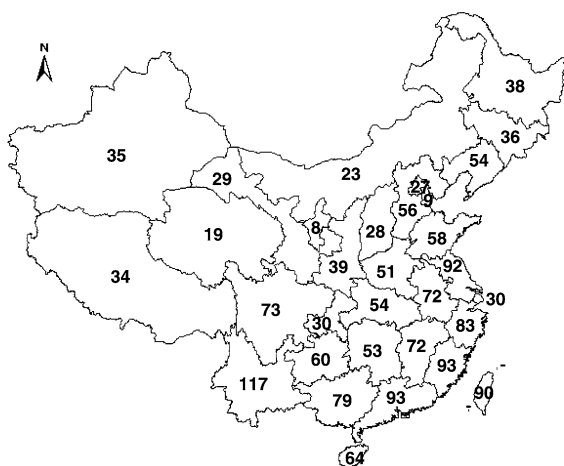


Fig. 2 Invasive alien plant species richness in provinces of China

Tianjin (9 species), and the highest species richness in Yunnan (94), followed by Taiwan (90). The proportion of invasive species among province floras ranged from 3.8% (Hubei province) to 0.5% (Qinghai province). A general trend of increasing invasive plant species richness from Northwest to Southeast was apparent (Fig. 2). Invasive plant species richness was correlated significantly with native species richness ($R^2 = 0.32$, $P = 0.002$) and with the number of endemic plant species (Fig. 3). Density of invasive plant species was correlated significantly with native species richness (Fig. 3) and with density of endemic plant species ($R^2 = 0.21$, $P = 0.017$). Multiple regression analysis showed that the most influential correlates of invasive plant species richness were native plant species richness and human population size (Table 1).

The 10 most widespread species included mostly annuals, growing in disturbed ruderal sites, e.g. *Conyza canadensis* or *Ipomoea purpurea* (Appendix 1). A number of species occurred only in one province (56 or 26.9% of those species for which distributional data were available). Some of the invaders reached high elevations and had a large altitudinal distribution, e.g. *Ipomoea purpurea* (0–2,800 m asl), *Lepidium densiflorum* (0–3,800 m asl), or *Sisymbrium altissimum* (0–2,500 m asl).

The invasive alien floras of the four biogeographic regions showed distinct similarities to each other (Table 2). Western China was most distinct from the South with regard to invasive alien plant species, whereas central and northeastern provinces had a strong similarity. Western China and the South still shared 48 invasive plant species.

Taxonomic position

The invasive plant species of China were represented by 59 families and 177 genera (Table 3). About 79.6% of the species belonged to dictyloedons and 20.4% to monocotyledons. There were no ferns, fern allies, or gymnosperms that are considered to be invasive. Asteraceae, Poaceae, and Brassicaceae contributed most to the invasive plants in terms of absolute numbers (Fig. 4). Thirty-five families were represented by one species only, and 50 families with five species or less. The three largest families accounted for 40.6% of all species.

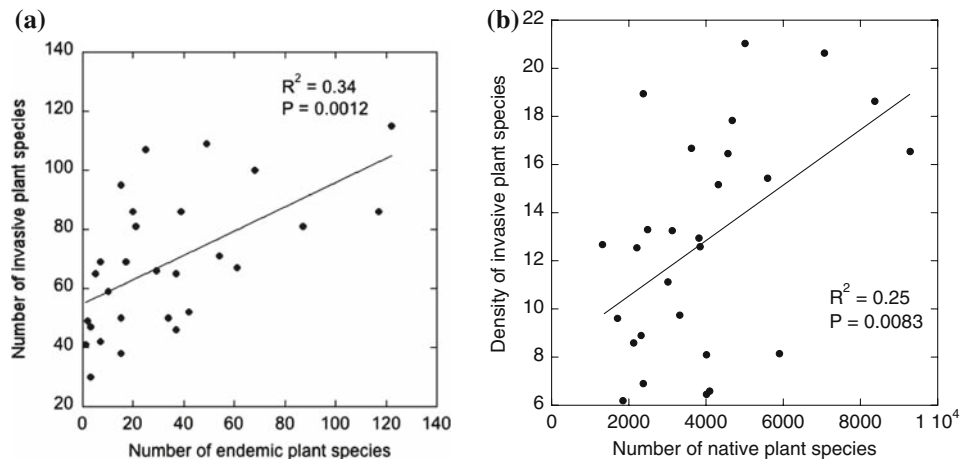


Fig. 3 Relationship between (a) invasive and endemic species richness, and (b) between density of invasive plant species and native species richness in 28 provinces of China

Table 1 Regression analyses showing the influence of geomorphological and socioeconomic factors on invasive plant species richness for 28 provinces in China

Source	df	Sum of squares	F	P
Area	1	429.4	2.29	0.145
Mid-latitude	1	530.5	2.83	0.107
Mid-longitude	1	187.6	1.00	0.328
Number of native plants	1	3841.4	20.48	0.0002
Population	1	831.8	4.43	0.047
Error	22	4126.9		

Table 2 Similarity of the invasive alien floras of four regions of China, e.g. western, southern, northeastern and central China

Region	West	South	Northeast	Central
West	–	42.5	59.4	51.5
South	188	–	48.3	67.1
Northeast	118	203	–	70.9
Central	147	298	155	–

Entries of the upper half are indices of similarity (Sørensen coefficient), of the lower half total numbers of species of the respective pair

The three major genera of invasive species were *Amaranthus*, *Ipomoea*, and *Solanum* (Table 4). Forty-seven or 26% of the genera contained only one species. Among the major genera, *Ipomoea* and *Lolium* contained most species that are invasive elsewhere. The proportion of species being invasive elsewhere was higher among monocotyledons than

Table 3 Summary statistics for the current invasive alien flora of China

	Dicotyledons	Monocotyledons	Total
Family	47	12	59
Genus	140	37	177
Species	215	55	270
Invasive elsewhere	69	29	98
Not invasive elsewhere	149	23	173

among dicotyledons ($\chi^2 = 10.2$, $P = 0.0014$), which is caused by the presence of many grasses in the former.

Geographic origins

Invasive plant species in China originated from all continents (Fig. 5). The fraction of invasive species from the New World totaled to 44.2%, with most species originating from South America. Other important source areas included Europe, North America, and other parts of Asia. Few species of Australian origin were present in China's invasive flora, and also few species whose native range lies solely within Asia. Species that are invasive elsewhere predominated in African and New World species. New World species were overrepresented among dicotyledons compared to Old World species ($\chi^2 = 7.48$, $P = 0.006$).

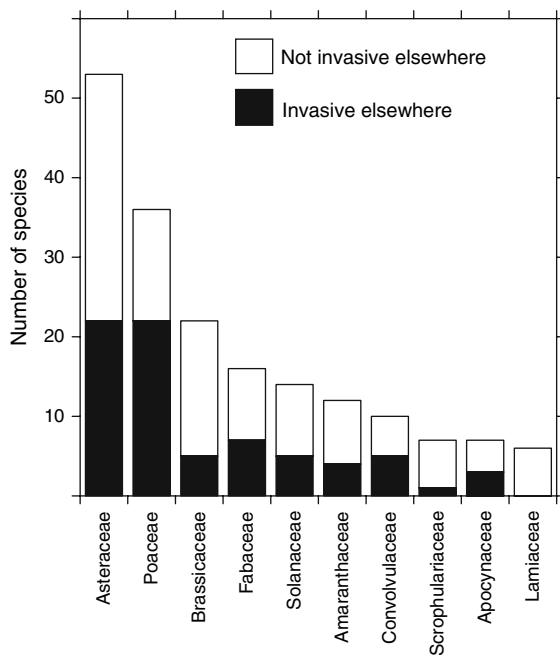


Fig. 4 The 10 major families with their numbers of invasive alien species of the Chinese flora

Table 4 Invasive alien species richness of the ten major genera of invasive plants in China

Genus	Invasive elsewhere	Not invasive elsewhere	Total
<i>Amaranthus</i>	2	7	9
<i>Ipomoea</i>	5	3	8
<i>Solanum</i>	2	5	7
<i>Veronica</i>	0	5	5
<i>Brassica</i>	1	3	4
<i>Euphorbia</i>	0	4	4
<i>Lepidium</i>	0	4	4
<i>Lolium</i>	2	2	4
<i>Ranunculus</i>	0	4	4
<i>Trifolium</i>	1	3	4

Life forms and habitats

The life form distribution was characterized by a prevalence of annuals and perennial herbs among the invasive plants (Table 5). The majority of climbers were vines of the genus *Ipomoea*, originating from the New World. Species being invasive elsewhere predominated among succulents and climbers. Woody perennials made only 9.6% of all invasive

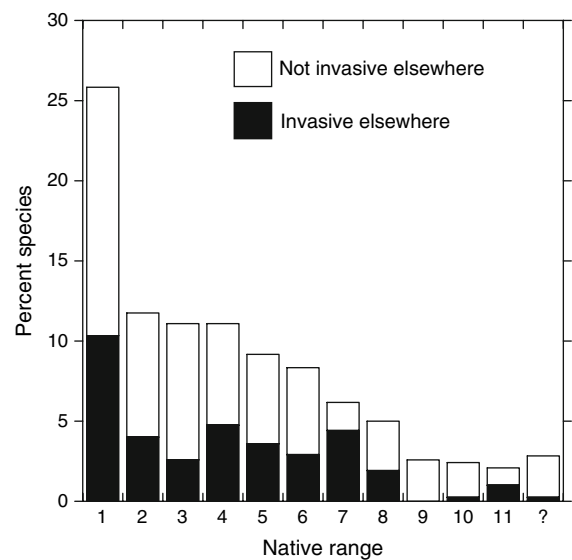


Fig. 5 The native ranges of invasive plant species of China ($N = 270$). Each species was allocated to one category only. 1 = South America, 2 = Africa, Eurasia, 3 = North America, 4 = North and South America, 5 = Europe, 6 = Eurasia, 7 = Africa, 8 = Central America, 9 = Asia, 10 = Australia, 11 = cosmopolitan, ? = unknown

Table 5 Distribution of invasive alien plants of China among life forms

Life form	IE	NE	IE/NE	Total	%
Annual	25	91	0.27	116	43.0
Annual or biennial	3	9	0.33	12	4.4
Biennial	4	7	0.57	11	4.1
Herbaceous perennial	40	42	0.95	82	30.4
Climber	10	3	3.30	13	4.8
Shrub	7	9	0.78	16	5.9
Tree	4	6	0.67	10	3.7
Free floating aquatic	2	3	0.67	5	1.8
Succulent	3	2	1.50	5	1.8

IE = invasive elsewhere, NE = not invasive elsewhere. Percentage refers to whole dataset

plants, aquatic plants only 1.8%. Herbs (annual to perennial) amounted to 81.9% of all species. The succulent species were members of *Opuntia* and *Bryophyllum*.

The invasive plant species were prevalent in disturbed grounds and in agricultural areas (Fig. 6). Species growing in ruderal sites (habitat type 1 in Fig. 6) were mostly not considered as being invasive

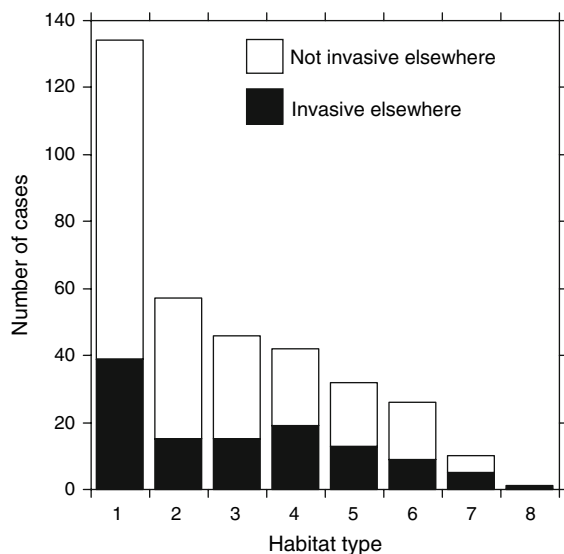


Fig. 6 Number of invasive alien plant species ($N = 181$) in various habitats of China. Species may occur in more than one habitat type. Habitats: 1 = Roadsides, railways, waste places, disturbed ground; 2 = agricultural areas, fields; 3 = grasslands, pastures, grassy slopes; 4 = tree plantations, afforestations; 5 = Lakeshores, riparian habitats; 6 = natural forests and forest margins; 7 = coastal areas; 8 = swamps, marshes

elsewhere. The relatively higher proportion of species invasive elsewhere was evident in species colonizing afforestations, tree plantations, and coastal areas. Thus, the ranking of species richness among habitats was different between species being invasive elsewhere and species not being invasive elsewhere.

Economic uses

The profile of economic uses demonstrates the prevalence of ornamentals among invasive plant species in China (Fig. 7). The 94 ornamentals identified included species from 75 genera and 40 families. The second most frequent economic use was medicinal plants. These species were made of 54% annuals, and the families Asteraceae and Brassicaceae contributed each with 11 species. Plants used as fodder or forage included 14 grass species but also species such as *Alternanthera philoxeroides* and *Eichhornia crassipes*. Among turf grasses, most of the species were also invasive elsewhere. The proportion of species not considered as invasive

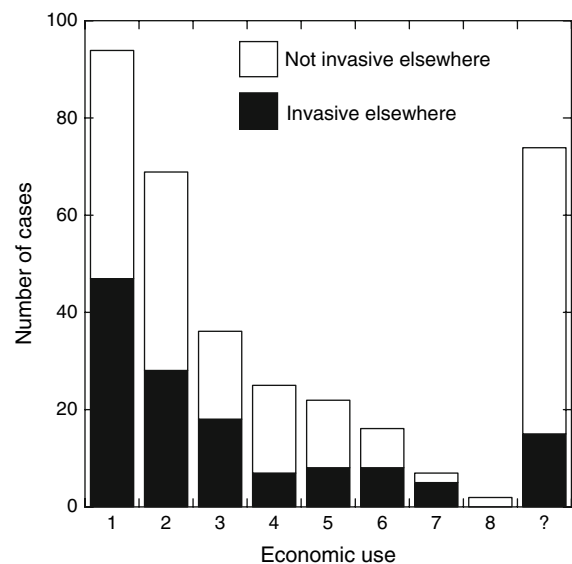


Fig. 7 Economic uses of invasive plant species ($N = 270$) of China. Medicinal plants include species that are used in folklore and species used for remedies. Invasive elsewhere refers to being harmful to natural areas (see text for explanations). Species may have been allocated to more than one category. 1 = ornamentals, 2 = medicinal plants, 3 = Fodder and forage, 4 = Food plants, 5 = Various materials, 6 = erosion control and soil improvement, 7 = turgrasses, 8 = other uses, ? = unknown or weed

elsewhere was the highest in food plants. The proportion of species being invasive elsewhere was higher in ornamentals than in non-ornamentals ($\chi^2 = 11.6$, $P < 0.001$). Weeds or species with unknown economic uses consisted of 65% annuals.

Discussion

Available data and species numbers

Compiling alien species for a given country has proved to be a useful approach to understanding plant invasion patterns (Rozefelds et al. 1999; Stadler et al. 2000; Silva and Smith 2004; Khuroo et al. 2007) and is the first step towards developing a management strategy for invasive species. Because we focused on invasive species, our species list certainly represents only a fraction of all naturalized alien plants within China's territories. Having such data would be indispensable but is currently not feasible to obtain. This represents a major gap of knowledge to be filled,

since complete floristic inventories of alien plants are essential for studying plant invasions (Pyšek et al. 2004).

Our data represent the current species pool of invasive plants and hence a snapshot in time. Since alien species spread and new species introductions are taking place, any floristic and biogeographic pattern will inevitably change over time. Previously published numbers of invasive plants in China differ markedly, e.g. 108 (Qiang and Cao 2000), 126 (Liu et al. 2006), 188 (Xu et al. 2006b). These differences are likely to reflect the dynamics of species naturalization as well as degree of knowledge. The list of Liu et al. (2005) does not include important invaders such as *Agave americana*, *Asparagus densiflorus* or *Robinia pseudoacacia*. We believe that our list represents the currently most updated compilation of invasive plant species in China.

The 270 invasive alien plant species make 0.9% of China's flora. The figure appears to be low compared to other regions. In California, for example, about 70 plant species are considered as serious invaders (Bossard et al. 2000), corresponding to 1.6% of the state's flora. The same has been observed for Taiwan, which has a much lower number of alien plants compared to Hawaii (8.1 and 43.8%, respectively, Wu et al. 2004b). Although plant introductions have a long history in China (Xie et al. 2001), large-scale introductions of species from other continents are a rather recent phenomenon and have probably not yet achieved the quantities of other regions in the world. The invasive perennial *Solidago canadensis* for example has been introduced into China in 1935 (Jin et al. 2004), whereas in Europe, the same plant was brought from North America in the 17th century (Weber 1998). According to Ding and Xie (1996), 837 plant species have been introduced into China up to 1970. International trade in China became important since the 1980s only but is now increasing rapidly (Normile 2004).

Status of species elsewhere and habitats

About one-third of the species reported here are serious invaders of natural areas in places outside of China, implying that there is considerable potential for damage to ecosystems in China. Whether those plant species are behaving similarly in China than in

other parts of the world is an open question that merits further investigations. Some species (e.g. *Ochrosia elliptica*, *Tradescantia zebrina*, *Voacanga africana*) are rather unknown as weeds or invaders in other parts of the world. More data on their ecology and impacts on ecosystems in China are needed, as such species may become new threats if introduced to other regions.

The fact that most plant species identified here are not serious invaders of natural habitats in other regions than China may reflect that these are primarily agricultural weeds; the majority of the species reported here occurred indeed on disturbed grounds and in arable fields. However, other habitat types representing more natural vegetation (forests, lake shores, wetlands) do also have a high fraction of species not being invaders of natural areas outside of China. Our categorization of habitats may be too broad to show whether these species are penetrating into undisturbed vegetation or whether they are confined to disturbed sites within these habitat types.

Life forms

The life form distribution among invasive plants was characterized by a high fraction of annuals and a remarkably low number of woody perennials. Whereas the high proportion of annuals in our dataset corresponds to other findings, e.g. Taiwan (Wu et al. 2004b), the number of woody taxa is likely to be underestimated. The reasons are most likely the lack of surveys and recordings of alien species in China. In other regions, shrubs and trees contribute greatly to the number of invasive alien plants (Binggeli 1996). We assume that there are many more woody naturalized species in China, for example *Pinus* sp., *Acacia* sp., and *Eucalyptus* sp. Pines and eucalypt trees are widely planted in China and are frequently escaping (S. Qiang, pers. comm.), and species of both genera are serious invaders in other regions (Richardson and Rejmánek 2004; Weber 2003). *Pinus radiata*, highly invasive in South Africa where it displaces species-rich native shrublands (Richardson and Brown 1986; Lavery and Mead 1998) is currently being evaluated as a tree for revegetating degraded lands and to reduce soil erosion (Yan et al. 2006). Whereas this is necessary, introducing and planting tree species that have proved to be damaging to

natural environments in other regions should be undertaken with great caution (Binggeli 1996). Also, *Casuarina equisetifolia*, a highly invasive tree of coastal areas in Florida and the Caribbean (Weber 2003), has been introduced to China and is being cultivated (Zhong et al. 2005). The status of these trees in terms of their naturalization potential needs to be assessed.

Among the invasive trees identified here, a number of species did have profound impacts on natural ecosystems elsewhere, e.g. *Leucaena leucocephala*, *Robinia pseudoacacia*, *Salix fragilis*. The latter is frequently planted for reforestations in China (Flora of China 2007) and has proved to change riparian ecosystems in New Zealand (Lester et al. 1994). Among shrubs, three species are of particular interest, e.g. *Acacia farnesiana*, *Chromolaena odorata*, and *Ulex europaeus*. All three species are widespread invaders of natural areas (Cronk and Fuller 1995; Weber 2003). Whereas *Chromolaena odorata* is well known as an invader in mainland and Taiwan of China (Peng and Yang 1998; Xie et al. 2001), no studies have addressed the ecology of *Acacia farnesiana* and *Ulex europaeus* in China.

The high fraction of annuals in our list may reflect a high number of agricultural weeds. Annuals contributed most to species not being serious environmental weeds elsewhere, indicating that they are mainly weeds of disturbed grounds. The high fraction of annuals may also be due to the large area of China located at high elevations. The invasive plants of the four western provinces (Fig. 1), having high mean altitudes, consisted mostly of annuals and short-lived perennials.

Taxonomy

It is not surprising that most invasive plants belong to large families. Global family size is a predictor for the number of alien plants in a flora (Weber 1997; Daehler 1998; Pyšek 1998; Li et al. 2001), and Asteraceae and Poaceae are also among the major families in the naturalized flora of Chinese Taiwan of China (Wu et al. 2004b). In contrast to Chinese Taiwan, the family Brassicaceae is an important source of invasive plants in mainland China. Other families, e.g. Amaranthaceae, Euphorbiaceae, Solanaceae and Convolvulaceae, are well represented in

alien floras of Asia (Zerbe et al. 2004; Wu et al. 2004b; Khuroo et al. 2007). The major genera contributing to invasive plants in China are also among the largest in the world, e.g. *Ipomoea*, *Solanum*, and *Euphorbia*. Some genera that provide many alien plants in Taiwan are missing in our list (e.g. *Crotalaria*, *Rumex*). However, many of the species in these genera are native to China. This is also the reason that *Polygonum* species did not appear in our list, although many species of *Polygonum* and *Rumex* are weedy in China (Li 1998).

Geographic origins and economic uses

As in most alien floras, species originated from all continents. However, South and North American species predominated among China's invasive plants, followed by Eurasian and African species. The profile of origins strongly resembles that of Europe's alien flora (Weber 1997) and the alien flora of Taiwan (Wu et al. 2004b). The large number of South American species invading Chinese habitats reflects the large area with a subtropical climate in this country.

Ornamentals contributed most to the invasive plants, which has been found for other countries and at a global scale (Reichard and White 2001; Mack and Erneberg 2002; Weber 2003). The large number of medical plants among the invasive flora is striking and makes the profile of economic uses different from that of other countries. One possibility might be that traditional Chinese medicine increasingly relies on alien species as native species become rarer. Overexploitation of native plants is one of the threats for rare species (López-Pujol et al. 2006). Well known invaders in this group include *Alliaria petiolata* or *Ipomoea cairica*. Grasses contributed mostly to forage and fodder plants but some species (e.g. *Spartina* spp.) have been planted for soil stabilizing.

Patterns of species richness of invasive plants within China

Within China, the proportion and number of invasive plants among provinces varies greatly. Overall, species richness and density of invasive plants among provinces were correlated with native species

richness and density. This is in accordance with other studies (Stohlgren et al. 1999; Sax 2002; Deuschewitz et al. 2003), and the positive relationship is most likely to reflect habitat diversity (Chong et al. 2001). However, the large size variation of provinces may mask any clear relationships and smaller spatial units than provinces would seem necessary for establishing accurate relationships between native and alien species richness (Stohlgren et al. 2006). The correlation between endemic and invasive species richness is obvious because larger province floras contain more endemics but demonstrates potential threats to the conservation of rare species. Field observations strongly suggest that many endemics and their habitats are threatened by invasive species (Lu et al. 2006).

Our regression analyses demonstrated that human population and native plant species richness are the best predictors for invasive plant species richness. These findings are similar to Liu et al. (2005), with the exception that in our study, latitude and longitude did not correlate with invasive species richness. However, Fig. 2 clearly suggests that southeastern provinces share more invasives than northwestern provinces. These are the most densely populated provinces and their ports recipients of international trade.

The variation in species richness also reflects China's markedly different topography, elevations, and climates (Ren 2000), so that a large diversity of habitats is given. It is therefore not surprising that the four biogeographic regions differ in their invasive floras. The western provinces Gansu, Qinghai, Xingjiang and Xizang (Tibet) are comprised of high plateaus and had the lowest similarity with the alien floras of the remaining biogeographic regions. It is, however, surprising that even there, the share of invasive plants includes 63 species, most of which are annual or short-lived herbs.

A number of invasive species in our list have been reported from high elevations, some of them occurring from sea level up to 2,500 m or more. Invasive plants growing in the western provinces are found at even higher elevations; the Qinghai-Tibet Plateau in the lower part of Western China has an average elevation of 4,000 m (Hou 1983). In other regions alien weeds have also been found to grow at high elevations (e.g. Pérez 1998; Daehler 2005; Khuroo et al. 2007).

The most widespread species included ornamentals (e.g. *Ipomoea purpurea*) and accidental introductions (e.g. *Lolium temulentum*). The latter entered China with the introduction of new wheat varieties (Ding and Xie 1996). Range sizes of alien plants are the product of species dispersal and human assisted dispersal, and some serious invaders have been planted. For example, the three aquatic plants *Alternanthera philoxeroides*, *Eichhornia crassipes*, *Pistia stratiotes* have been planted extensively throughout China in the 1950s because they were regarded as beneficial (Ding and Xie 1996). Thus, the distribution of any alien plant species cannot be understood without knowing their history.

Outlook

Many invasive plants in China are yet confined to few provinces and likely have not yet reached their distribution limits. This could be shown for *Solidago canadensis*, based on an estimation of its potential distribution range in China (Lu et al. 2007). However, accurate data on the distribution are scarce, and systematic surveys are badly needed.

China's fast economic growth and increasing international trade will foster biological invasions and invasive species will inevitably become more important here (Weber and Li, in press). Several authors stress that the increasing trade between eastern Asia and the United States will lead to the introduction of new invaders on both sides (Guo 2002; Callaway et al. 2006; Jenkins and Mooney 2006), asking for close collaborations between these nations. China, with its yet low number of invasive species may rely on experiences of other countries and take appropriate measures to counteract new invasions. It is therefore urgent to have baseline data on the invasive species pool in China and to accelerate research on invasive species. Needed are risk assessments of beneficial species intended for introduction. For example, in Liaoning province, a trial was conducted along a highway to control *Ambrosia artemisiifolia* by planting shrubs or large herbs (e.g. *Amorpha fruticosa*, *Coronilla varia*, *Helianthus tuberosus*) with the aim to replace rag weed (Ding and Xie 1996). However, all three species are alien to China and are serious invaders of natural areas elsewhere (Weber 2003).

Distribution data for native and alien species at regional and local scales are necessary to draw conclusions on the invasion potential and on ecological damages by invasive alien species. Considering the extraordinary species richness and extent of endemism of China's flora, even at low elevations, the potential of serious impacts on native species is high. Punctual observations support this connotation; *Mikania micrantha* for example is rapidly spreading in southern China, smothering trees and shrubs, killing them and replacing the original species-rich vegetation (Zhuang 1999, cited in Qiang 2005). Similarly, crofton weed (*Eupatorium adenophorum*) covers now more than 300,000 km² in southwestern China, invading forests, grasslands and decreasing biodiversity (Qiang 1998).

An increase of awareness and knowledge of invasive species in China is a prerequisite for setting up a national management strategy in the sense of McNeely et al. (2001). Intensified research on the ecology of invasive species in China and the development of proper control techniques seems necessary.

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Appendix

Appendix 1 Invasive alien plant species in China

Species	Family	Lifeform	Origin or native range	Provinces	Habitats
<i>Acacia farnesiana</i>	Fabaceae	Sh	NAm, SAm	9	
<i>Acanthospermum australe</i>	Asteraceae	An	SAm	2	1, 5
<i>Aegilops squarrosa</i>	Poaceae	An	Eurasia		2, 3
<i>Aeschynomene indica</i>	Fabaceae	An	NAm	1	
<i>Agave americana</i>	Agavaceae	Su	NAm	8	1, 3
<i>Ageratum conyzoides</i>	Asteraceae	An	SAm	13	1, 2, 4, 5, 7
<i>A. houstonianum</i>	Asteraceae	An	CAm		1, 2
<i>Agrostemma githago</i>	Caryophyllaceae	An	NAfr, Eurasia	5	1, 2, 3
<i>Alliaria petiolata</i>	Brassicaceae	An	Eurasia	2	1, 2, 5, 6
<i>Aloe vera</i>	Liliaceae	Su	Afr	1	
<i>Alternanthera philoxeroides</i>	Amaranthaceae	Pe	SAm	19	1, 5
<i>A. pungens</i>	Amaranthaceae	Pe	SAm	4	1
<i>Alyssum alyssoides</i>	Brassicaceae	An	NAfr, Eurasia	1	1
<i>Amaranthus albus</i>	Amaranthaceae	An	NAm	3	1
<i>A. blitoides</i>	Amaranthaceae	An	NAm		1, 2
<i>A. caudatus</i>	Amaranthaceae	An	SAm		1
<i>A. hybridus</i>	Amaranthaceae	An	SAm	10	1, 3
<i>A. polygonoides</i>	Amaranthaceae	An	CAm	3	1
<i>A. retroflexus</i>	Amaranthaceae	An	SAm	12	1
<i>A. spinosus</i>	Amaranthaceae	An	SAm	7	1
<i>A. tricolor</i>	Amaranthaceae	An	Asia		1, 2
<i>A. viridis</i>	Amaranthaceae	An	SAm	21	1, 2
<i>Ambrosia artemisiifolia</i>	Asteraceae	An	NAm	17	1, 2, 4
<i>A. trifida</i>	Asteraceae	An	NAm	15	1, 2, 4
<i>Anredera cordifolia</i>	Basellaceae	Vi	SAm	6	
<i>Anthemis arvensis</i>	Asteraceae	An	NAfr, Eurasia		1, 2

Appendix 1 continued

Species	Family	Lifeform	Origin or native range	Provinces	Habitats
<i>Apium leptophyllum</i>	Apiaceae	An	SAm	9	1, 4, 5
<i>Armoracia rusticana</i>	Brassicaceae	Pe	Eur	5	2
<i>Asclepias curassavica</i>	Asclepiadaceae	Pe	Tropics	16	1, 2
<i>Asparagus densiflorus</i>	Liliaceae	Pe	Afr	28	
<i>A. setaceus</i>	Liliaceae	Vi	Afr	28	
<i>Aster subulatus</i>	Asteraceae	An	NAm	7	1
<i>Atriplex nummularia</i>	Chenopodiaceae	Pe	Aus	1	
<i>Axonopus compressus</i>	Poaceae	Pe	NAm, SAm	6	3, 5, 6
<i>Avena fatua</i>	Poaceae	An	Afr, Eurasia	32	1, 3
<i>A. sterilis</i>	Poaceae	An	Afr, Eurasia	1	
<i>Bidens frondosa</i>	Asteraceae	An	NAm	5	1, 4
<i>B. pilosa</i>	Asteraceae	An	SAm	21	1
<i>Brachiaria eruciformis</i>	Poaceae	An	Afr, Eurasia		5
<i>B. mutica</i>	Poaceae	Pe	SAm		2, 3, 4
<i>B. plantaginea</i>	Poaceae	Pe	Afr, SAm	1	
<i>Brassica juncea</i>	Brassicaceae	An	Asia	28	1, 2
<i>B. kaber</i>	Brassicaceae	An	Eur		2
<i>B. rapa</i> subs. <i>campestris</i>	Brassicaceae	An	?	1	
<i>B. tournefortii</i>	Brassicaceae	An	Afr, Eurasia	1	
<i>Bromus catharticus</i> var. <i>catharticus</i>	Poaceae	An	SAm		5
<i>Bryophyllum pinnatum</i>	Crassulaceae	Su	Afr	5	
<i>Buchloe dactyloides</i>	Poaceae	Pe	NAm		1, 3
<i>Cabomba caroliniana</i>	Cabombaceae	Aq	SAm	3	5
<i>Callisia repens</i>	Commelinaceae	Pe	NAm, SAm	1	1
<i>Cameraria latifolia</i>	Apocynaceae	Tr	NAm, SAm	1	
<i>Cannabis sativa</i>	Cannabaceae	An	Asia	1	2
<i>Capsella bursa-pastoris</i>	Brassicaceae	An	?	28	1, 2, 3
<i>Cassia mimosoides</i>	Fabaceae	An	Tropics		1, 2
<i>C. occidentalis</i>	Fabaceae	An	Tropics		1, 5
<i>C. tora</i>	Fabaceae	Sh	Asia		1, 5
<i>Catharanthus roseus</i>	Apocynaceae	Pe	Afr	8	
<i>Cenchrus echinatus</i>	Poaceae	An	Tropics	5	
<i>C. pauciflorus</i>	Poaceae	An	NAm, SAm		
<i>Centaurea cyanus</i>	Asteraceae	An	Eurasia	1	
<i>Chenopodium ambrosioides</i>	Chenopodiaceae	Pe	NAm, SAm	10	1
<i>C. giganteum</i>	Chenopodiaceae	An	Asia	12	
<i>C. hybridum</i> subsp. <i>hybridum</i>	Chenopodiaceae	An	Eurasia	18	3, 6
<i>Chromolaena odorata</i>	Asteraceae	Sh	CAm, SAm	6	1, 4, 5
<i>Chrysanthemum carinatum</i>	Asteraceae	An	NAfr		1, 2
<i>C. coronarium</i>	Asteraceae	An	NAfr, Eurasia		1, 5
<i>Conium maculatum</i>	Apiaceae	An	Afr, Eurasia	1	2, 6
<i>Conyza bonariensis</i>	Asteraceae	An	SAm	12	1, 4
<i>C. canadensis</i>	Asteraceae	An	NAm, SAm	28	1, 2, 3, 5
<i>C. sumatrensis</i>	Asteraceae	An	SAm	13	
<i>Cordyline fruticosa</i>	Liliaceae	Pe	?	4	

Appendix 1 continued

Species	Family	Lifeform	Origin or native range	Provinces	Habitats
<i>Coreopsis grandiflora</i>	Asteraceae	Pe	NAm		1, 4
<i>C. lanceolata</i>	Asteraceae	Pe	NAm		3, 4
<i>C. tinctoria</i>	Asteraceae	An	NAm	2	1, 2
<i>Coriandrum sativum</i>	Apiaceae	An	Eur		1, 4
<i>Coronopus didymus</i>	Brassicaceae	An	SAm	11	1, 4
<i>Cosmos bipinnatus</i>	Asteraceae	An	CAm, SAm		3, 4
<i>C. sulphureus</i>	Asteraceae	An	CAm, SAm		1, 3, 4
<i>Crassocephalum crepidioides</i>	Asteraceae	An	Afr	15	
<i>Cyclachaena xanthiifolia</i>	Asteraceae	An	NAm	1	
<i>Cyperus rotundus</i>	Cyperaceae	Pe	Tropics	29	
<i>Datura innoxia</i>	Solanaceae	An	CAm	1	
<i>D. metel</i>	Solanaceae	An	NAm	7	1, 3
<i>D. stramonium</i>	Solanaceae	An	CAm	27	1, 3
<i>Daucus carota</i>	Apiaceae	Pe	Afr, Eurasia	8	1, 3
<i>Deutzia crenata</i>	Hydrangeaceae	Sh	Asia	7	
<i>Digitalis purpurea</i>	Scrophulariaceae	Pe	NAfr, Eur	4	1
<i>Digitaria ciliaris</i>	Poaceae	An	?	1	
<i>Diplotaxis muralis</i>	Brassicaceae	An	NAfr, Eurasia	1	7
<i>Duranta erecta</i>	Verbenaceae	Sh	NAm, SAm	8	1
<i>Ehrharta erecta</i>	Poaceae	An	Afr		1
<i>Eichhornia crassipes</i>	Pontederiaceae	Aq	SAm	19	5
<i>Eleusine indica</i>	Poaceae	Pe	Paleotropics	30	
<i>Elsholtzia communis</i>	Lamiaceae	Pe	?	1	
<i>Erigeron annuus</i>	Asteraceae	An	NAm	28	1, 4
<i>E. philadelphicus</i>	Asteraceae	Pe	NAm	6	1, 6
<i>Eryngium foetidum</i>	Apiaceae	Pe	SAm	5	1, 5, 6
<i>Etlingera elatior</i>	Zingiberaceae	Pe	Asia	1	6
<i>Eupatorium adenophorum</i>	Asteraceae	Pe	CAm	5	1, 2, 3, 4
<i>E. catarium</i>	Asteraceae	An	SAm	2	
<i>Euphorbia dentata</i>	Euphorbiaceae	An	CAm, NAm	1	
<i>E. hirta</i>	Euphorbiaceae	An	Tropics	8	
<i>E. maculata</i>	Euphorbiaceae	An	NAm	9	
<i>E. marginata</i>	Euphorbiaceae	An	NAm	1	
<i>Eutrema wasabi</i>	Brassicaceae	Pe	Asia	1	5
<i>Evolvulus nummularius</i>	Convolvulaceae	Pe	?	1	1
<i>Galinsoga parviflora</i>	Asteraceae	An	CAm, SAm	27	1, 4, 5
<i>Geranium carolinianum</i>	Geraniaceae	An	CAm, NAm	11	
<i>Gomphrena celosioides</i>	Amaranthaceae	An	SAm	3	1
<i>Helenium autumnale</i>	Asteraceae	Pe	NAm	1	1
<i>Helianthus annuus</i>	Asteraceae	An	NAm	1	
<i>H. petiolaris</i>	Asteraceae	An	NAm	1	
<i>H. tuberosus</i>	Asteraceae	Pe	NAm		1, 4, 5
<i>Heliotropium europaeum</i>	Boraginaceae	An	NAfr, Eurasia	3	1, 2, 5
<i>Hesperis matronalis</i>	Brassicaceae	An	Eurasia	1	
<i>Hibiscus trionum</i>	Malvaceae	An	Afr, Eurasia	25	1, 4

Appendix 1 continued

Species	Family	Lifeform	Origin or native range	Provinces	Habitats
<i>Hyptis rhomboidea</i>	Lamiaceae	An	CAm	4	1
<i>H. suaveolens</i>	Lamiaceae	An	SAm	5	1
<i>Ipomoea alba</i>	Convolvulaceae	Vi	NAm, SAm	9	1, 5, 6
<i>I. cairica</i>	Convolvulaceae	Vi	?	6	1
<i>I. carnea</i>	Convolvulaceae	Sh	NAm, SAm	3	
<i>I. hederacea</i>	Convolvulaceae	Vi	NAm, SAm	1	
<i>I. indica</i>	Convolvulaceae	Vi	Pantropic	3	6, 7
<i>I. lacunosa</i>	Convolvulaceae	Vi	NAm	1	
<i>I. nil</i>	Convolvulaceae	An	Pantropic	24	1, 3
<i>I. purpurea</i>	Convolvulaceae	Vi	SAm	27	1, 2, 5, 6
<i>Jacquemontia tamnifolia</i>	Convolvulaceae	An	NAm, SAm	1	
<i>Lantana camara</i>	Verbenaceae	Sh	SAm	6	1, 4, 7
<i>Lemna trinervis</i>	Lemnaceae	Aq	NAm, SAm	3	
<i>Lepidium campestre</i>	Brassicaceae	An	Eurasia	1	1, 2, 3
<i>L. densiflorum</i>	Brassicaceae	An	NAm		1, 5, 7
<i>L. sativum</i>	Brassicaceae	An	NAfr, Asia	6	
<i>L. virginicum</i>	Brassicaceae	An	CAm, NAm	19	1, 2, 3, 4
<i>Leucaena leucocephala</i>	Fabaceae	Tr	SAm	9	
<i>Leucanthemum vulgare</i>	Asteraceae	Pe	Eurasia		4
<i>Lilium hansonii</i>	Liliaceae	Pe	Asia	1	5
<i>Linum usitatissimum</i>	Linaceae	An	?	1	
<i>Lobularia maritima</i>	Brassicaceae	Pe	NAfr, Eurasia	9	1
<i>Lolium multiflorum</i>	Poaceae	An	NAfr, Eurasia	16	1, 2, 3
<i>L. perenne</i>	Poaceae	Pe	NAfr, Eurasia		4
<i>L. persicum</i>	Poaceae	An	Asia		2
<i>L. temulentum</i>	Poaceae	An	Eur	30	2
<i>Macfadyena unguis-cati</i>	Bignoniaceae	Vi	CAm, SAm	2	
<i>Malvastrum coromandelianum</i>	Malvaceae	Pe	Pantropic	6	1, 4
<i>Martynia annua</i>	Pedaliaceae	Pe	CAm, SAm	1	1, 6
<i>Medicago hispida</i>	Fabaceae	An	NAfr, Eurasia		1, 4
<i>Mikania micrantha</i>	Asteraceae	Vi	CAm, SAm	1	1, 4, 6
<i>Mimosa invisa</i>	Fabaceae	Pe	SAm	2	
<i>M. pudica</i>	Fabaceae	Pe	SAm	6	1, 6
<i>Mirabilis jalapa</i>	Nyctaginaceae	An	SAm	18	1
<i>Narcissus tazetta</i>	Amaryllidaceae	Pe	NAfr, Eurasia	2	1
<i>Nasturtium officinale</i>	Brassicaceae	Pe	NAfr, Eurasia	18	5, 8
<i>Nerium oleander</i>	Apocynaceae	Tr	Afr, Eurasia	1	
<i>Nicandra physalodes</i>	Solanaceae	An	Sam	7	1
<i>Nymphaea alba</i>	Nymphaeaceae	Aq	NAfr, Eurasia	4	5
<i>Ochrosia elliptica</i>	Apocynaceae	Tr	Aus, Pac	2	
<i>Oenothera erythrosepala</i>	Onagraceae	An	Eur		4, 5
<i>O. rosea</i>	Onagraceae	Pe	CAm, SAm	3	
<i>Opuntia ficus-indica</i>	Cactaceae	Su	CAm	5	1, 2
<i>O. monacantha</i>	Cactaceae	Su	SAm	5	6
<i>O. stricta</i> var <i>dillenii</i>	Cactaceae	Su	NAm, SAm	3	

Appendix 1 continued

Species	Family	Lifeform	Origin or native range	Provinces	Habitats
<i>Orobanche brassicae</i>	Orobanchaceae	An	?	1	
<i>Oxalis corymbosa</i>	Oxalidaceae	Pe	SAm	12	4
<i>Panicum maximum</i>	Poaceae	Pe	Afr	6	
<i>Papaver nudicaule</i>	Papaveraceae	Pe	Eur	8	
<i>Parthenium hysterophorus</i>	Asteraceae	An	CAm, SAm	6	2, 3
<i>Parthenocissus quinquefolia</i>	Vitaceae	Vi	CAm, NAm		4, 6
<i>Paspalum conjugatum</i>	Poaceae	Pe	SAm	11	
<i>P. dilatatum</i>	Poaceae	Pe	SAm	4	1, 2, 3
<i>P. fimbriatum</i>	Poaceae	An	CAm, SAm		1
<i>Passiflora foetida</i>	Passifloraceae	Vi	NAm, SAm	6	
<i>Pennisetum glaucum</i>	Poaceae	An	?	1	
<i>P. setosum</i>	Poaceae	Pe	Tropics		3
<i>Peperomia pellucida</i>	Piperaceae	An	SAm	5	2, 6, 7
<i>Persicaria pensylvanica</i>	Polygonaceae	An	NAm	1	
<i>Phalaris minor</i>	Poaceae	An	NAfr, Eurasia		2, 4
<i>P. paradoxa</i>	Poaceae	An	NAfr, Eurasia		
<i>Physalis peruviana</i>	Solanaceae	Pe	SAm	4	1
<i>P. philadelphica</i>	Solanaceae	An	CAm	2	1, 3
<i>P. pubescens</i>	Solanaceae	An	NAm, SAm	3	1, 6
<i>Phytolacca americana</i>	Phytolaccaceae	Pe	NAm	18	1, 6
<i>Pilea microphylla</i>	Urticaceae	An	CAm, SAm	6	
<i>Pistia stratiotes</i>	Araceae	Aq	Afr, SAm	17	
<i>Pittosporum tobira</i>	Pittosporaceae	Tr	Asia	10	1, 3, 6, 7
<i>Plantago aristata</i>	Plantaginaceae	An	NAm	1	
<i>P. lanceolata</i>	Plantaginaceae	Pe	NAfr, Eurasia		5, 7
<i>P. virginica</i>	Plantaginaceae	An	NAm	10	1, 2, 5
<i>Poa compressa</i>	Poaceae	Pe	NAfr, Eurasia		1, 3
<i>Polymnia uvedalia</i>	Asteraceae	Pe	NAm	1	
<i>Pseudelephantopus spicatus</i>	Asteraceae	Pe	CAm, SAm		1, 3
<i>Pyrethrum parthenifolium</i>	Asteraceae	Pe	Eurasia		1
<i>Ranunculus arvensis</i>	Ranunculaceae	An	NAfr, Eurasia	2	1, 4
<i>R. muricatus</i>	Ranunculaceae	An	NAfr, Eurasia	3	1, 2, 3
<i>R. sardous</i>	Ranunculaceae	An	NAfr, Eurasia	1	1
<i>R. trachycarpus</i>	Ranunculaceae	An	?	1	3
<i>Raphanus raphanistrum</i>	Brassicaceae	An	NAfr, Eurasia	3	1, 2
<i>Rapistrum rugosum</i>	Brassicaceae	An	NAfr, Eurasia	1	1
<i>Rauvolfia cubana</i>	Apocynaceae	Sh	CAm	1	
<i>Reseda lutea</i>	Resedaceae	An	NAfr, Eurasia	1	1, 3
<i>Rhus typhina</i>	Anacardiaceae	Tr	NAm	1	
<i>Rhynchelytrum repens</i>	Poaceae	Pe	Afr, Asia	4	
<i>Ribes multiflorum</i>	Grossulariaceae	Sh	Eur	6	
<i>R. nigrum</i>	Grossulariaceae	Sh	Eurasia	3	1, 6
<i>R. uva-crispa</i>	Grossulariaceae	Sh	NAfr, Eurasia	6	1
<i>Ricinus communis</i>	Euphorbiaceae	An	Afr	25	4, 5, 6
<i>Robinia pseudoacacia</i>	Fabaceae	Tr	NAm		1, 6

Appendix 1 continued

Species	Family	Lifeform	Origin or native range	Provinces	Habitats
<i>Rosmarinus officinalis</i>	Lamiaceae	Sh	NAfr, Eurasia	28	
<i>Salix fragilis</i>	Salicaceae	Tr	Eurasia	3	
<i>Salvia coccinea</i>	Lamiaceae	An	NAm, SAm	1	
<i>Saponaria officinalis</i>	Caryophyllaceae	Pe	Eurasia	1	1
<i>Scoparia dulcis</i>	Scrophulariaceae	An	SAm	6	1, 4
<i>Senecio dubtabilis</i>	Asteraceae	An	Eur	6	
<i>S. vulgaris</i>	Asteraceae	An	Cosmopolitan	15	1, 2, 3
<i>Sesbania exaltata</i>	Fabaceae	Pe	NAm	1	
<i>Setaria palmifolia</i>	Poaceae	Pe	Asia	2	1
<i>S. parviflora</i>	Poaceae	Pe	NAm, SAm	1	
<i>Sida rhombifolia</i>	Malvaceae	Pe	Pantropic	1	
<i>S. spinosa</i>	Malvaceae	Pe	Pantropic	1	
<i>Silybum marianum</i>	Asteraceae	An	NAfr, Eur		1, 2, 4
<i>Sinapis alba</i>	Brassicaceae	An	NAfr, Eurasia	9	1, 3
<i>Sisymbrium altissimum</i>	Brassicaceae	An	Eurasia	3	1, 2, 3
<i>Solanum aculeatissimum</i>	Solanaceae	An	SAm	12	1, 3, 6
<i>S. capsicoides</i>	Solanaceae	Pe	SAm	9	1, 6
<i>S. chrysotrichum</i>	Solanaceae	Sh	CAm, SAm	2	
<i>S. erianthum</i>	Solanaceae	Sh	NAm, SAm	9	1
<i>S. seaforthianum</i>	Solanaceae	Vi	NAm, SAm	1	1
<i>S. sisymbriifolium</i>	Solanaceae	An	SAm	2	
<i>S. torvum</i>	Solanaceae	Pe	CAm, SAm	8	1
<i>Solidago canadensis</i>	Asteraceae	Pe	NAm	6	1, 4
<i>Soliva anthemifolia</i>	Asteraceae	An	SAm	7	1, 2, 4
<i>Sorghum alnum</i>	Poaceae	Pe	SAm	1	
<i>S. halepense</i>	Poaceae	Pe	NAfr, Asia	15	1
<i>S. sudanense</i>	Poaceae	An	Afr		1, 2
<i>Spartina alterniflora</i>	Poaceae	Pe	NAm, SAm	4	7
<i>S. anglica</i>	Poaceae	Pe	Eur	11	7
<i>Spergula arvensis</i>	Caryophyllaceae	An	NAfr, Eurasia	5	3, 5
<i>Spermacoce latifolia</i>	Rubiaceae	Pe	SAm	4	
<i>Stachytarpheta jamaicensis</i>	Verbenaceae	Pe	CAm, SAm	6	3
<i>Stellaria apetala</i>	Caryophyllaceae	An	Eur	4	1, 2
<i>Symphytum officinale</i>	Boraginaceae	Pe	Eurasia	1	6
<i>Synedrella nodiflora</i>	Asteraceae	An	CAm, SAm	6	1
<i>Tagetes erecta</i>	Asteraceae	An	CAm, SAm		1
<i>T. patula</i>	Asteraceae	An	CAm, SAm		1
<i>Talinum paniculatum</i>	Portulacaceae	An	NAm, SAm		1, 5
<i>Tectona grandis</i>	Lamiaceae	Tr	Asia, Pac	5	
<i>Tithonia diversifolia</i>	Asteraceae	Pe	CAm		1, 4
<i>Tradescantia spathacea</i>	Commelinaceae	Pe	SAm	1	
<i>T. zebrina</i>	Commelinaceae	Pe	CAm	4	
<i>Tridax procumbens</i>	Asteraceae	Pe	CAm, SAm	5	1, 4
<i>Trifolium hybridum</i>	Fabaceae	Pe	NAfr, Eurasia	1	
<i>T. incarnatum</i>	Fabaceae	An	Eur		1, 2, 3

Appendix 1 continued

Species	Family	Lifeform	Origin or native range	Provinces	Habitats
<i>T. pratense</i>	Fabaceae	Pe	NAfr, Eurasia		1, 2, 3
<i>T. repens</i>	Fabaceae	Pe	NAfr, Eurasia	23	1, 2, 3
<i>Ulex europaeus</i>	Fabaceae	Sh	Eur	1	1, 3
<i>Vaccaria segetalis</i>	Caryophyllaceae	An	NAfr, Eurasia	8	2
<i>Veronica arvensis</i>	Scrophulariaceae	An	NAfr, Eurasia	9	1, 3, 4
<i>V. hederifolia</i>	Scrophulariaceae	An	NAfr, Eurasia	2	1, 2
<i>V. peregrina</i>	Scrophulariaceae	An	NAm, SAm	18	1
<i>V. persica</i>	Scrophulariaceae	An	Asia	16	1, 2
<i>V. polita</i>	Scrophulariaceae	An	NAfr, Eurasia	20	1
<i>Vetiveria zizanioides</i>	Poaceae	Pe	Asia	7	
<i>Vinca minor</i>	Apocynaceae	Pe	Eur	1	
<i>Voacanga africana</i>	Apocynaceae	Tr	Afr	1	
<i>Waltheria indica</i>	Sterculiaceae	Sh	NAm, SAm	6	
<i>Wedelia trilobata</i>	Asteraceae	Pe	CAm, SAm	4	1, 3
<i>Xanthium spinosum</i>	Asteraceae	An	SAm	4	1, 4
<i>X. strumarium</i>	Asteraceae	An	CAm, SAm	1	1
<i>Zephyranthes candida</i>	Amoryllidaceae	Pe	SAm	8	
<i>Z. carinata</i>	Amoryllidaceae	Pe	CAm	8	
<i>Zinnia peruviana</i>	Asteraceae	An	NAm, SAm		1, 3

Names in bold indicate species that are invasive in natural areas in other countries than China. Lifeform: An = annual or short-lived perennial herb, Aq = aquatic plant, Pe = perennial herb, Sh = shrub, Su = succulent, Tr = tree, Vi = vine or liana. Origins: Afr = Africa, Aus = Australia, Eur = Europe, CAm = Central America, NAm = North America, SAm = South America, NAfr = North Africa, Pac = Pacific, ? = unknown. Provinces: number of provinces in which the species is present. Habitats: 1 = roadsides, railways, waste places, disturbed ground; 2 = agricultural areas, fields; 3 = grasslands, pastures, grassy slopes; 4 = tree plantations, afforestations; 5 = lakeshores, riparian habitats; 6 = natural forests and forest margins; 7 = coastal areas; 8 = swamps, marshes

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